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DISEASES THREATENING BANANA BIODIVERSITY IN UGANDA

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ABSTRACT

Banana (*Musa* spp.) is the most important food crop in Uganda as indicated by consumption rate, annual production (9.5 M t ha^{-1}) and agricultural land committed to the crop. This level of productivity (6.3 t ha^{-1} yr^{-1}) is extremely low when compared to the yields obtained on station and well-managed plantations (60 t ha^{-1} yr^{-1}). Previous diagnostic studies attributed the low productivity to diseases, pests, soil fertility decline, limited post harvest utilisation options and socioe-conomic problems. The susceptibility to pests and diseases is largely attributed to the narrow genetic base of banana in Uganda. Recent on station and on-farm studies suggest the major diseases threatening banana biodiversity in Uganda include: 1) Black Sigatoka which severely affects all East African Highland (EA-AAA) banana cultivars and a range of introduced genotypes; 2) Fusarium wilt which affects several introduced genotypes though all EA - AAA bananas are resistant; 3) Banana streak virus causing different levels of infection on all types of banana cultivars; and 4) Banana bacterial wilt, a recent outbreak affecting all types of banana in Mukono and Kayunga districts (central Uganda). This paper illustrates the potential threat posed by the above diseases to *Musa* biodiversity in Uganda and highlights some of the recent studies undertaken to control the diseases.

Key Words: Banana diseases, genetic base, *Musa* spp.

RÉSUMÉ

La banane (*Musa* spp.) est la nourriture la plus importante en Ouganda comme indiqué par le taux de consommation, la production annuelle (9.5 M t ha^{-1}) est la terre cultivée assignée à la plante. Ce niveau de productivité (6.3 t ha^{-1} an^{-1}) est extrêmement faible quand on le compare aux rendements obtenus sur stations et des plantations bien aménagées (60 t ha^{-1} an^{-1}). Des études antérieures ont attribué la faible productivité à des maladies, pestes, la diminution de la fertilité du sol, des options limitées d'utilisation lors de la récolte et des contraintes socio-économiques. La susceptibilité aux pestes et maladies est largement attribuée à une faible base génétique de la banane en Ouganda. Des études récentes sur station et sur terrain suggèrent que les maladies majeures menaçant la diversité de la banane incluent: 1) black sigatoka qui affecte sévèrement toutes les variétés de bananas des hautes terres de l'Afrique de l'Est (EA-AAA) et une gamme des génotypes introduits. 2) le Fusarium qui affecte plusieurs génotypes introduits malgré le fait que toutes les EA-AAA sont résistantes; 3) le virus de raie de la banane causant différents niveaux d'infection sur toutes les variétés de la banane, et 4) le champignon de la banane, une nouvelle éruption affectant toutes les variétés de la banane dans les districts de Mukono et Kayunga (au centre de l'Ouganda). Cet article illustre la menace potentielle posée par les maladies ci hautes citées de la diversité de la banane et fait mention des études récentes entreprises pour contrôler ces maladies.

Mots Clés: Banane maladies, base génétique, *Musa* spp.

INTRODUCTION

The banana is one of the most important cash and food crops in Uganda. However, its survival is currently threatened by a host of pests and diseases, which are gradually driving some popular cultivars out of production and making banana production a less profitable enterprise. The diseases that constitute the biggest threat to *Musa* biodiversity in Uganda include: Fusarium Wilt, Black Sigatoka, banana streak virus and banana bacterial wilt.

Fusarium wilt. Fusarium wilt, caused by the soil fungus *Fusarium oxysporum* Schlec f.sp.*cubense* (E.F.Sm) Snyder & Hansen (FOC), is one of the most destructive diseases of banana in Uganda, where entire plots of susceptible cultivars have been completely wiped out. The disease was identified in Uganda for the first time in 1952 (Leaky, 1970). Currently, it is found all-over the country, wherever susceptible banana clones are cultivated. It exclusively attacks introduced (exotic) cultivars and has not been observed on the dominant highland bananas (EA-AAA), which are endemic in the region. The four exotic cultivars susceptible to this disease in Uganda are; Bogoya (Gros Michel - AAA), Kayinja (Pisang awak – ABB), Sukali Ndizi and Kisubi (Ney Poovan– AB). The pathogen (FOC) is known by the asexual stage and has been particularly characterised by four differential cultivars into pathogenic races of which only race 1 (differential cultivar, Gros Michel) has been reported in Uganda (Kangire *et al.*, 2001). Although FOC, has also been characterised into more than 20 vegetative compatibility groups (Ploetz, 1990), their field pathogenicity has not been properly defined. Due to the narrow genetic base within the locally cultivated bananas, there are efforts to introduce other cultivars from elsewhere and evaluate them for suitability and resistance to pests and diseases, which has been a continuous process.

Black Sigatoka. Black Sigatoka, caused by the fungus *Mycosphaerella fijiensis* Morelet, is considered to be the most important leaf spot disease of the banana. The disease causes premature drying of leaves which in turn leads to incomplete filling of banana fingers. It was first described in Fiji in the early 1960s (Stover, 1972) and was first reported in Uganda in 1989 (Tushemereirwe and Waller, 1993). By 1992 its distribution was restricted to areas which had mean minimum annual temperatures above 15°C. Since then, continued monitoring in the areas proximal to previously noted infested sites has not revealed significant progress of the disease to cooler areas. A yield loss assessment study conducted at Kawanda (1994-6) revealed a bunch weight reduction of 37% (Tushemereirwe *et al.*, 2000).

Banana streak virus (BSV). Banana streak virus (Genus *Badnavirus)* (BSV) was first reported in Uganda in 1990 (Dabek and Waller, 1990). Jones and Lockhart (1993) reported up to 90% yield losses on "Poyo" plants with severe BSV symptoms. In severely infected areas in Uganda, plantations had almost 100% loss in saleable yield (Tushemereirwe *et al.*, 1996).

The BSV exists in different forms; integrated and episomal forms (Harper *et al.*, 1999). It is believed that the integrated forms exist in a diverse range of Musa genotypes (Ndowora and Lockhart, 1999). Some genotypes contain integrant sequences comprising part of the badnavirus genome that are rearranged and partially inverted and therefore very stable. This integrant is linked to A – genome and is considered incapable of being excited for episomal expression. It is therefore, believed that badnavirus integrant in AAA may not easily be excited by stresses. Those cultivars with B-genome, however, contain integrants that may be excited by stresses like tissue culture conditions to episomal forms infectious, transmitted by mealybug vectors (*Planococcus citri* (Risso); *Saccharicoccus sacchari* (Cockerell; *Dysmicoccus brevipes* Cockerell) (Lockhart and Olszewski, 1993; Hong-Ji Su, 1998; Kubiriba *et al.*, 2001). A wide range of genotypes may therefore be infected by BSV.

Bacterial wilt. This disease caused by a bacterium, *Xanthomonas campestris* pv. m*usacearum,* was first reported on the banana in Ethiopia where it was known to cause wilt in Ensete (a relative of bananas). Yirgou and Bradbury (1974), describe the first symptoms on the leaf. In flowered plants the disease leads to premature ripening and infected

fingers appear discolored in cross section. Farmers in Mukono reported a disease with similar symptoms in late 2001.

This report highlights reactions of different banana cultivars/clones to the major banana diseases as observed in survey studies or on-station trials.

MATERIALS AND METHODS

Fusarium wilt. The Fusarium Wilt results reported in this paper were collected from a trial conducted at Kawanda Agricultural Research Institute (KARI). Nine banana cultivars including the host differential for the FOC race currently known in Uganda, Gros Michel (race 1), were planted in a field previously occupied by susceptible cultivars (Kisubi, Bogoya, Sukari-ndiizi and Kayinja) at Kawanda, during the month of June 1999. The trial was a completely randomised design with 15 replicates, and 15 plants per cultivar, and was planted in a field with severe infestation of the fusarium wilt pathogen. Inoculum of the pathogen in the field was enhanced by chopping and digging-in infected banana plants. Both tissue culture plants and young suckers were used as planting materials. The field was kept weed free and routine pruning and de-suckering was practiced. Observation of external symptoms of fusarium wilt, as well as assessment of corm damage at harvest was done. Corm damage assessment, was done by cutting cross sections as recommended by Orjeda (1998).

Black Sigatoka. The reaction of banana cultivars to black Sigatoka was assessed in the farmers fields at 12 sites in central Uganda during a diagnostic survey conducted in 1991-2. All recently flowered plants in a selected plot of 25 banana mats of mixed cultivars were sampled. The variables, youngest leaf with Black Sigatoka spots (YLS) and youngest leaf with banana leaf speckle (YLC) were used to score the disease and were recorded over a period of two years.

Banana streak virus. Thirty farms were selected in nine villages of Ntungamo district, south western Uganda. Severity data (Severity score: 0-3 scale) was then collected on 7 most infected farms planted with mainly East African highland banana cultivars in mixed stands every month for a period of one year. Mean severity for the farms ranged from 0.65 to 0.792 and mean incidence ranged from 72.5% to 97.5%. Data was transformed and subjected to GLM procedure in SAS. Means for the different cultivars were then combined for the different clonal sets and then separated using LSD at p-level = 0.05.

Banana bacterial wilt. A team of plant pathologists from KARI and Mukono district extension workers visited the affected area on 4th and 7th September 2001, respectively. Among the farmers visited was Mr. Musiitwa of Bulyanti village, who first reported the disease and whose plantation was the most severely affected. Several other neighbouring plantations were also visited and disease assessment done. Samples of diseased tissues were also collected for local isolation and identification of the causal pathogen. More samples were sent to CABI Bioscience, U.K for further isolation and identification of the causal organisms. Farmers and extension workers were asked to report any new sightings of the disease.

RESULTS AND DISCUSSION

Fusarium wilt. Results (Table 1) suggest that clones FHIA 25, FHIA 21 and PITA 16 appear to be resistant to fusarium wilt. Whereas FHIA 25 was as resistant as Williams (reference clone for resistance), FHIA 21 and PITA 16 were mildly attacked but demonstrated sufficient resistance that prevented them from completely succumbing to the disease. Any cultivars damaged by the disease above score 3 (in cross section, was considered to be susceptible (Table 1).

When compared with Gros Michel (susceptible reference clone), the following cultivars appeared susceptible to the disease: Pisang ceylan, TMBS 22788-11, TMBX 22595-2, and TMBX 1378. External symptoms of leaf discolouration were also evident of the susceptibility. However, field observations on Pisang ceylan, showed that despite its susceptibility to the disease, it was quite resistant to black sigatoka disease and could yield acceptable bunches, while both Gros Michel and Williams were highly susceptible to the disease.

In addition to its resistance to *Fusarium* Wilt and Sigatoka diseases, FHIA 25 gave high bunch

yields with maximum bunch weight of 52 kgs. The most susceptible cultivars (TMBS 22788-11, TMBX 22595-2, and TMBX 1378) also gave low bunch yields with *Fusarium* Wilt damage negatively correlated with bunch yield (-0.31) at 0.01%.

These results suggest that FHIA 25 and FHIA 21 clones can be introduced to farmers who are currently facing the *Fusarium* Wilt problem. On-station post-harvest studies already suggest that FHIA 25 is a good beer/juice banana but can also be boiled with beans/groundnuts and served as 'food'. FHIA 21 passes well as a roasting banana but can also be used in Waragi (local gin) brewing. PITA 16, though resistant to *Fusarium* Wilt still has a problem of being non-parthenocarpic (have plenty of seeds) and no use has yet been identified for this cultivar.

Black Sigatoka. When individual cultivars were compared with the standard reference cultivars (Table 2) all the highland banana clones were in the susceptible range (95% confidence interval) or more susceptible than Gros Michel (Bogoya), a standard susceptible reference clone for black sigatoka. No highland clone was in the reaction range of Kayinja (ABB) (95% confidence interval), a cultivar resistant to black sigatoka. However, there appeared to be significant variation in cultivar response to both sigatoka leaf spots and banana leaf speckle.

The most abundant banana clutivars used by Ugandan farmers are the East African Highland AAA and the exotic ABB cultivars. Whereas the ABB group is known to be resistant to Sigatoka leaf spots, the reaction of East African AAA to the pathogens was not clear at the time of this study. Preliminary results of this study appeared to indicate that sigatoka leaf spots development on all encountered highland cultivars either was faster or at the same speed as on Gros Michel (Bogoya), a known susceptible cultivar. These results suggested that most (or all) cultivars in the AAA East African group were susceptible to black sigatoka.

The plantains (AAB) such as Gonja developed sigatoka as fast as Gros Michel suggesting that they are all susceptible. They also appeared to get moderate banana leaf speckle damage suggesting lower levels of resistance to this disease in comparison with other non-indigenous cultivars.

The Ndiizi (AB) group had the same number of unspotted leaves as Gros Michel suggesting that it was susceptible. It, however, appeared resistant to banana leaf speckle. The Kayinja (ABB) group was the only clone that appeared resistant to black sigatoka leaf spots. It also appeared resistant to banana leaf speckle.

TABLE 1. Effect of fusarium wilt disease on recently accessed banana clones (15 plants each) in an evaluation trial at KARI

Cultivars	Damage levels (scores)		Mean bunch weight
	Scores 2-3	Scores 4-6	
Williams *	0	0	16.9
FHIA 21	1	0	18.9
FHIA 25	0	0	48.0
G/Michel **	1	6	20.0
PITA 16	1	0	23.0
Pisang ceylan	0	5	20.0
TMBS 22788-11	1	9	13.7
TMBS 22595-2	0	9	12.6
TMBX 1378	0	10	11.8
S.E.D	-	-	5.2

Disease damage level was scored from 1-6 (see Gisella Orjeda, 1998
* = Standard reference for resistant clones
** = Standard reference for susceptible clones

Banana streak virus. Most cultivars reacted similarly to BSV infection with slight variability. The severity score recorded for BSV on Embiire, Enjagata, Entaragaza, Enyeru, Mbwazirume and Rwamugongo was similar but slightly lower than the score recorded on Bukumu and Nyakyinika and higher than that recorded on Enzirabushera, Kibuzi, Butobe, Enzirabahima and Magyeya (Table 3). All the five clonal sets reacted in a similar manner to BSV infection (Table 4).

TABLE 2. Reaction of different cultivars to Sigatoka leaf spots and banana leaf speckle as indicated by the position of youngest leaf with mature lesions at Ugandan survey sites in central Uganda.

Cultivar		*YLS	SE	YLC	SE	TL	SE	N
Salalugazi	AAA	3.9	0.1	4.0	0.1	5.5	0.1	236
Kibalawo	AAA	3.9	0.2	4.0	0.2	5.4	0.2	48
Nakyetengu	AAA	4.0	0.1	4.0	0.1	5.7	0.1	212
Malira-omun	AAA	4.0	0.1	4 0	0.1	4.9	0.2	127
Kibuzi	AAA	4.1	0.1	4.1	0.1	5.6	0.1	262
Malira-luvu	AAA	4.1	0.3	4.1	0.3	5.3	0.3	27
Namwezi	AAA	4.2	0.1	4.2	0.1	5.8	0.1	231
Mbwazirume	AAA	4.2	0.2	4.2	0.2	5.7	0.2	96
Kiyovu	AAA	4.3	0.2	4.3	0.2	5.6	0.2	56
Katwalo	AAA	4.3	0.2	4.1	0.2	5.9	0.2	58
Nalugolima	AAA	4.3	0.2	4.4	0.2	6.1	0.2	68
Ndiibwa	AAA	4.4	0.1	4.4	0.1	5.8	0.1	224
Ntika	AAA	4.4	0.1	4.3	0.1	5.8	0.1	236
Lusumba	AAA	4.4	0.1	4.3	0.1	5.5	0.1	145
Malira	AAA	4.5	0.5	4.5	0.5	5.6	0.3	16
Musakala	AAA	4.5	0.1	4.7	0.1	6.1	0.1	224
Mukutula	AAA	4.7	0.5	5.2	0.6	6.8	0.4	14
Kafuba	AAA	4.7	0.3	4.7	0.2	6.0	0.2	71
Nfuuka	AAA	4.7	0.1	4.6	0.1	6.1	0.1	452
Muvubo	AAA	4.7	0.1	4.6	0.1	6.3	0.1	150
Namwanyu	AAA	4.8	0.3	4.5	0.3	6.4	0.4	22
Nassaba	AAA	4.9	0.1	4.9	0.1	6.3	0.1	316
Mutangen	AAA	4.9	0.1	4.9	0.2	6.0	0.2	101
Nakitembe	AAA	4.9	0.1	4.9	0.1	6.2	0.1	474
Kisansa	AAA	5.0	0.1	4.9	0.1	6.4	0.1	216
Siira	AAA	5.0	0.2	5.0	0.2	6.5	0.2	107
Nakabulu	AAA	5.1	0.1	4.9	0.1	6.4	0.1	219
Bukumo	AAA	5.2	0.7	5.2	0.7	7.2	0.6	25
Ituntu	AAA	5.3	0.9	5.3	0.9	7.5	0.8	16
Kafunze	AAA	5.3	0.8	4.9	0.7	6.4	0.6	10
Kisubi	AB	5.4	0.1	-		6.6	0.1	136
Gonja	AAB	5.4	0.2	5.1	0.3	7.3	0.2	64
Endunda	AAA	5.4	0.3	5.3	0.3	6.5	0.3	29
Bogoya #	AAA	5.4	0.3	5.2	0.4	7.4	0.3	66
Ndizi	AB	5.5	0.2	-		6.9	0.2	84
Nandigobe	AAA	5.5	0.4	5.5	0.3	7.6	0.3	61
Enyamaizi	AAA	5.6	0.3	5.4	0.3	5.9	0.5	12
Likhago	AAA	5.7	0.1	5.7	0.1	7.2	0.1	510
Lwaddungu	AAA	6.1	0.5	5.9	0.4	6.8	0.3	16
Kayinja ##	ABB	7.3	0.1	-		7.7	0.1	244

*

\# : standard susceptible reference clone
; Standard resistant reference clone
N : Number of plants assessed
YLS : Position of youngest leaf with mature Sigatoka sports
YLWC : Position of youngest leaf with mature cladosporium speckle lesions.
SE : .Standard error of mean
TL : .Total number of functional leaves (retaining some green colouration) at flowering
-:Monitorable symptoms did not develop (all leaves free)

The BSV isolates are both genetically and serologically very diverse (Lockhart and Olszewski, 1993; Ndowora and Lockhart, 1999) with 11 'species' reported in Uganda (Harper and Hull, Pers. Comm.). It may therefore not be surprising for BSV to infect most these cultivars since they belong to the same genotype (AAA-EA).

Banana bacterial wilt. The disease reported by the farmers had symptoms that matched those described by Yirgou and Bradbury (1974). Cross sections of diseased petioles or pseudostems revealed yellowish droplets of bacteria oozing from vascular bundles, while the fruit ripened unevenly and prematurely with cross sections showing unique yellowish blotches in the flesh of fingers and dark brown placental scars. Affected plants also showed pronounced wilting of the male bud bracts and a characteristic bacterial oozing in the peduncle.

Results of samples sent to CABI bio-science (UK) confirmed the disease reported in Mukono district as banana bacterial wilt caused by *Xanthomonas campestris* pv. m*usacearum*. This was the first time bacterial wilt (Enset wilt) disease was being reported in Uganda and there is no information regarding the mechanism of introduction.

The disease was observed on both Highland (Matooke) and exotic (dessert/beer) bananas although the former were the dominant types in the fields and therefore most affected (Table 5). In one particular field, the incidence was estimated at 70% although according to the farmer, some of the affected stools had been slashed and rouged out in an attempt to control the disease. It was therefore difficult to tell the symptoms on such stools by mere observation of uprooted stumps. Despite all this, it was evident that the incidence in some of the surrounding fields was considerably high.

According to a number of farmers interviewed, the disease was first observed around October 2000 in Mr. Musiitwa's banana plantation. Since then it has spread to several plantations in the surrounding areas. The team and farmers failed to guess the likely origin of the disease. It first appeared in a plantation that was over seven years old suggesting it may not have been transmitted with the planting material. It was clear from the farmers interviewed that the source of the problem was the planting materials obtained from local sources within their area.

In Mukono and Kayunga districts, where the disease was identified, bananas are ranked as the leading food crop. It was suggested that spread of this disease could easily be enhanced through exchange of planting materials or banana trade between the neighbouring districts and sub-

TABLE 3. Cultivar reaction to BSV infection

Cultivar	Mean severity score
Bukumu (AAA-EA)	1.100 ± 0.032 a
Nyakinyika (AAA-EA)	0.782 ± 0.235 ab
Embiire (AAA-EA)	0.618 ± 0.057 abc
Enjagata (AAA-EA)	0.773 ± 0.102 abc
Entaragaza (AAA-EA)	0.709 ± 0.122 abc
Enyeru (AAA-EA)	0.681 ± 0.054 abc
Mbwazirume (AAA-EA)	0.622 ± 0.105 abc
Rwamugongo (AAA-EA)	0.457 ± 0.324 abc
Enzirabushera (AAA-EA)	0.503 ± 0.096 bc
Kibuzi (AAA-EA)	0.534 ± 0.068 bc
Butobe (AAA-EA)	0.509 ± 0.011 bc
Enzirabahima (AAA-EA)	0.324 ± 0.124c
Magyeya (AAA-EA)	0.280 ± 0.230c

TABLE 4. Clonal set reaction to BSV infection

Clonal set	Mean severity score
Beer	0.549 ± 0.015a
Musakala	0.508 ± 0.070 a
Nakabululu	0.532 ± 0.016a
Nakitembe	0.570 ± 0.174 a
Nfuuka	0.549 ± 0.014a

TABLE 5. Reaction of the common banana types to Bacterial Wilt disease in Uganda

Cultivars	Disease response
Highland bananas (AA-EA)	Susceptible
Bogoya (Gros Michel) (AAA)	Susceptible
Gonja (AAB)	Susceptible
Kisubi (AB)	Susceptible
Kayinja (ABB)	Susceptible
Sukali Ndiizi (AB)	Susceptible

counties. In response, the government imposed quarantine, in the affected areas of Kayunga and Mukono, to contain further spread of the disease. Affected farmers were also advised to aggressively destroy and bury all affected plants to reduce further spread. A need to develop a research strategy on appropriate control measures and determine epidemiology and spread of the disease, was also highlighted. Research has already been initiated to address these important issues.

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